12/2450

X-4920

INSTRUCTION
MANUAL

Precision Pulse Generator
MODEL PB-1

BNC BERKELEY NUCLEONICS COMPANY

2/2450
X-4920

Precision Pulse Generator
MODEL PB-1

BERKELEY NUCLEONICS COMPANY
1429 Oregon St., Berkeley 2, California • Phone: THornwall 5-8680

SER. NO. 108

Warranty

Berkeley Nucleonics Company warrants all instruments, including component parts (except semi-conductors) to be free from defects in material and workmanship, under normal use and service for a period of one year. If repairs are required during the warranty period, contact the factory for shipping instructions. Shipping is the responsibility of the owner of the instrument. This warranty is void if the unit is repaired or altered by others than those authorized by the Berkeley Nucleonics Company.

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SPECIFICATIONS

SECTION 1

The Model PB-1 is a precision pulse generator designed to test stability, linearity, repetition-rate and rise-time effects in many linear pulse measuring and amplifying instruments. A unique feature of the Model PB-1 is its 0.1% linearity and stability at frequencies higher than 100 kc. It outmodes the presently used mercury-relay pulse generator for the above tests and performs double duty as a general purpose pulse generator.

FREQUENCY: 1 cps to 1 mc, continuously adjustable.

WIDTH: 0.3 to 10 μsec, continuously adjustable. Tail pulse to 100 μsec.

DUTY FACTOR: 50% max.

OUTPUT AMPLITUDE: 10.1 v max direct coupled. Fine adjustment by ten-turn potentiometer. Coarse adjustment by step attenuator.

AMPLITUDE RANGES:

Attenuator at	Range	Accuracy Full Scale
x 1	0.1 v - 10.1 v	± 0.5%
x 10	10 mv - 1.01 v	± 2%
x 100	1 mv - 101 mv	± 3%

Note: This instrument has attenuators on all amplitude ranges and may be adjusted to the degree of accuracy of the test equipment.

INTEGRAL LINEARITY; Better than 0.1%.

DIFFERENTIAL LINEARITY: Better than 1% (ten point test from 0.3 v to 9.3 v).

OUTPUT IMPEDANCE: 100 ohms, ± 1%.

POLARITY: Positive or negative.

RISE TIME: 0.05 - 2 μsec in 5 steps (into 1K load).

FALL TIME: 0.1 - 100 μsec depending on loading resistance and capacitance.

STABILITY: Change of output amplitude with:

(a) temperature: from 25° - 55°C less than 0.1% (0.0033%/°C), or 1 mv, whichever is greater,
(b) line voltage: less than 0.03% from 105 - 125 vac,
(c) time: drift less than 0.03% for 48 hr with constant temperature and line voltage.

OUTPUT LOADING: For 0.1% linearity and stability, max. average output current is 0.25 ma, and min load resistance is 1K. See Sec. 2.1, 2.2, and 2.3.

AMPLITUDE SHIFT WITH DUTY FACTOR: Depends on load resistance and position of amplitude potentiometer. See Sec. 3.3.

OVERSHOOT: Approximately 10 mv switching transient into 1K load. May be reduced by rise-time integrator or attenuator.

DROOP: Less than 0.1% at max pulse width into 1K load.

AMPLITUDE JITTER: Less than 0.01%.

TRIGGER OUTPUT: 2 v positive pulse, 40 nsec rise time, 0.1 μsec width, 120 ohms output impedance. Coincident with leading edge of output pulse.

EXT TRIGGER: 1 v pos pulse, 0 to 1 mc, rise time less than 1 msec.

DC REFERENCE VOLTAGE: 0.1 - 10.15 vdc from 500 ohm AMPLITUDE potentiometer. Stability and linearity same as output pulse. Voltage available on pin jacks at rear of chassis.

MAX AMBIENT OPERATING TEMPERATURE: 60°C.

POWER REQUIREMENTS: 105 - 125 vac, 60 cps, 10 watts, 220 vac available.

MECHANICAL DIMENSIONS: Standard relay rack mounting, 19 in. wide, 3 1/2 in. high, 12 1/8 in. deep, aluminum alloy chassis.

FINISH: Grey anodized cabinet; baked enamel, grey-blue panel.

WEIGHT: 10 lb., net.

OPERATING INFORMATION

SECTION 2

2.1 PRINCIPLE OF OPERATION

The Model PB-1 is a precision instrument and it is essential to understand the principles of operation before using it. Sections 2.1, 2.2, and 2.3 contain the minimum information needed to illustrate these principles.

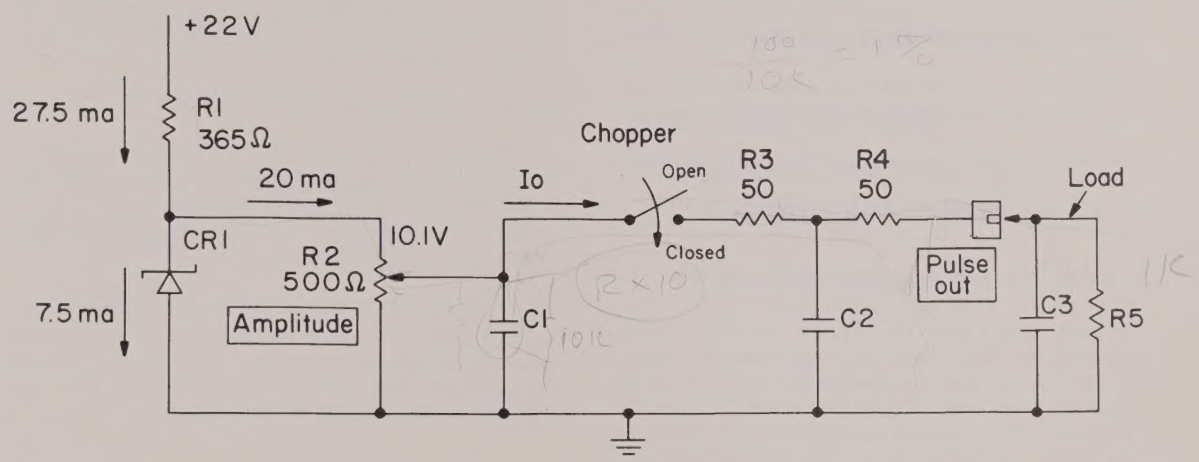


Fig. 1. Simplified diagram of Model PB-1.

Refer to the simplified schematic of the Model PB-1 in Fig. 1. A current of 27.5 ma from the 22 v supply passes through R1 and divides between the zener diode, CR1, and the 10-turn AMPLITUDE potentiometer, R2. The zener current is 7.5 ma, required for 0.001%/°C TC (temperature coefficient). The remaining 20 ma passes through the potentiometer.

The output of the potentiometer is connected to a capacitor, C1. The chopper samples the voltage across C1, producing pulses of defined amplitude which are passed to the output connector through R3 and R4 (100 ohms output impedance). The repetition rate and closure time of the chopper are controlled by the front panel FREQUENCY and WIDTH controls, respectively.

Capacitor C2 (with R3, R4, and R5) integrates the pulse and may be switched out or increased by the front panel RISE TIME control. Load capacitance, C3, also integrates the pulse; therefore, the output cable should be as short as possible for fastest rise time.

The peak pulse current is determined by the AMPLITUDE setting and load resistance. The average current is determined by the duty factor of the chopper, as discussed next.

2.2 PEAK CURRENT, AVERAGE CURRENT AND DUTY FACTOR

A distinction between peak and average current should be made. If a 1 v battery is loaded with 1K, the average and peak current are the same, 1 ma. However, if a pulse generator delivers 1 v, 1 μsec pulses into 1K with a pulse spacing of 10 μsec, the peak current is still 1 ma but the average current is 0.1 ma, since the pulse is present only 10% of the time. Another way of stating this is the duty factor is 10% (or 0.1 as a ratio). Duty factor (DF) is defined as:

DF = pulse width/pulse spacing.

Now the relation between peak current, average current, and duty factor may be summarized:

peak current = pulse amplitude/load resistance

average current = peak current x DF.

2.3 HIGH DUTY FACTOR OPERATION

Referring again to Fig. 1, as the average current, Io, increases, the capacitor, C1, begins to discharge, and the charge is replenished between pulses from the AMPLITUDE potentiometer. The drain on the potentiometer causes its output voltage to sag. The percentage voltage sag varies with the wiper arm position, which is the main reason for nonlinearity at high DF.

Additionally, the zener diode voltage sags because it is relinquishing some of its current to the potentiometer. The zener impedance is 30 ohms, so a 1 ma change of current causes a 30 mv sag. Also, the prescribed current of 7.5 ma for 0.001%/°C TC no longer exists (although a variation of ±1 ma zener current does not affect the specified TC of 0.0033%/°C for the instrument.)

In view of the above considerations, the specified average output current of 0.25 ma should not be exceeded for 0.1% linearity. Effects of greater average current on linearity and amplitude shift are discussed in Sec. 3.1 and 3.3.

The limit on peak pulse current is 10 ma for 0.1% linearity and stability. This limitation is set by the chopper and is discussed in Sec. 3.2.

If the load resistance is less than 1K and a 10 v output pulse is required, it will be necessary to interpose an emitter-follower between the Model PB-1 and the unit under test. Unless special precautions are taken, temperature stability may suffer in this case.

The Model PB-1 may be used in general purpose applications into 50 ohms at maximum duty factor without effecting its accuracy into 1K. However, many of the specifications of Sec. 1 will no longer hold.

2.4 FREQUENCY AND WIDTH

The FINE frequency and width controls are located above their respective coarse controls. The FINE controls are uncalibrated but have scales for reference and resetting. The ranges overlap by at least 10%.

The pulse width at half height depends upon the value of the load resistance and capacitance as discussed below under tail pulses. To avoid ambiguity, the coarse WIDTH control markings refer to the flat top of the pulse.

It is possible at high frequencies for long pulses to ride up the tail of each other. This occurs particularly at large load impedances and will appear as a base-line shift. Smaller load resistances will minimize it.

2.5 POLARITY

The polarity switch reverses the pulse polarity while leaving the base-line at ground.

2.6 AMPLITUDE CONTROL AND ATTENUATOR

The 10-turn AMPLITUDE control in conjunction with the ATTENUATOR provides a dynamic range of 10,000:1 from 10.1 v to 1 mv. With the ATTENUATOR set at x1 the full scale accuracy is 10.1 v ± 50 mv into an open circuit. The minimum reading is 0.1 v ± 10 mv.

Since the output impedance is 100 ohms, a loading of even 10K will change the readings by 1%. The load impedance modifies the calibrated AMPLITUDE setting as follows:

$$\text{Pulse Ampl.} = \frac{\text{AMPL. setting} \times \text{load}}{100 + \text{load}}$$

where load is in ohms.

It is important to recognize that there is a loading effect of the ATTENUATOR in the x10 and x100 positions as if there were external load resistances: in the x10 position the loading is 1K; in the x100 position, 10K.

2.7 RISE TIME CONTROL

Any capacitive or resistive loading will affect both the rise and fall times as discussed in Sec. 3.5 The calibrations on the RISE TIME control apply for pulses fed through about 4 ft. of RG 58/U into a 1K termination.

The RISE TIME control is also used for filtering the switching transients of the chopper, if so desired.

2.8 DC REFERENCE VOLTAGE

The dc reference voltage, available at rear panel pin jacks, is obtained from the wiper arm of R2 (see Fig. 1). The resistive loading should be larger than 100K so as not to affect the pulse amplitude accuracy. The voltage available is 0.1 to 10.15 v at either polarity and at 0.1% linearity and stability. The front panel ATTENUATOR does not affect this reference voltage.

2.9 AC POWER AND FUSE

The power cord has a 3 pin grounding type connector. The ground pin is connected to chassis ground.

The fuse is 0.2 A Slo-Blo at 115 vac. If 230 vac is used, change the fuse to 0.1 A Slo-Blo.

APPLICATIONS

SECTION 3

3.1 LINEARITY

Integral linearity of an instrument is measured by (a) linearly increasing the input amplitude, (b) plotting the input vs output amplitudes, and (c) observing the deviation of this plot from a straight line. Differential linearity is measured by increasing the input pulse amplitude in equal increments and observing the nonequality of the output increments.

The integral linearity of the Model PB-1 is 0.1%. Since there are 1,000 divisions on the AMPLITUDE dial, the possible error is ± 1 division. The lower the AMPLITUDE setting, the greater the percentage error. Therefore, for best linearity, the AMPLITUDE control should be operated near its upper end and the ATTENUATOR used for small pulses.

Observe that the attenuator accuracy is $\pm$ 2% on the x10 scale and $\pm$3% on the x100 scale. Therefore, it will generally be necessary to slightly reset the AMPLITUDE control when switching ranges so the edges of one range coincide with another. For example, when checking the linearity of a pulse height analyzer, an AMPLITUDE setting of 100 on the x1 scale may produce pulses in channel 50. But a setting of 1,000 with x10 attenuation may produce a pulse in channel 49. It will be necessary to increase the AMPLITUDE control until the pulse reappears in channel 50 before continuing with the tests.

It is often desirable to check linearity at frequencies up to 500 kc. As discussed in Secs. 2.1, 2.2, and 2.3, the linearity depends upon the output loading. Optimum operation of the Model PB-1 is obtained with less than 0.25 ma average current output. However, the accuracy is still high at a greater loading. Fig. 2 shows the degree of linearity obtained under various loading conditions.

If the ATTENUATOR is at x10, the major load resistance is an internal 1K; at x100, it is 10K.

The differential linearity of the Model PB-1 is given as 1% for a ten point test from 0.3 to 9.3 v, each increment being 1 v or 100 divisions. If smaller increments are taken, the error will be larger. Hence, 0.5 v increments will increase the differential nonlinearity to 2%. A lower limit of 0.3 v should be observed in these tests because the error at the 0.1 v setting (which is the zero of the AMPLITUDE control) may be of the order of 5%.

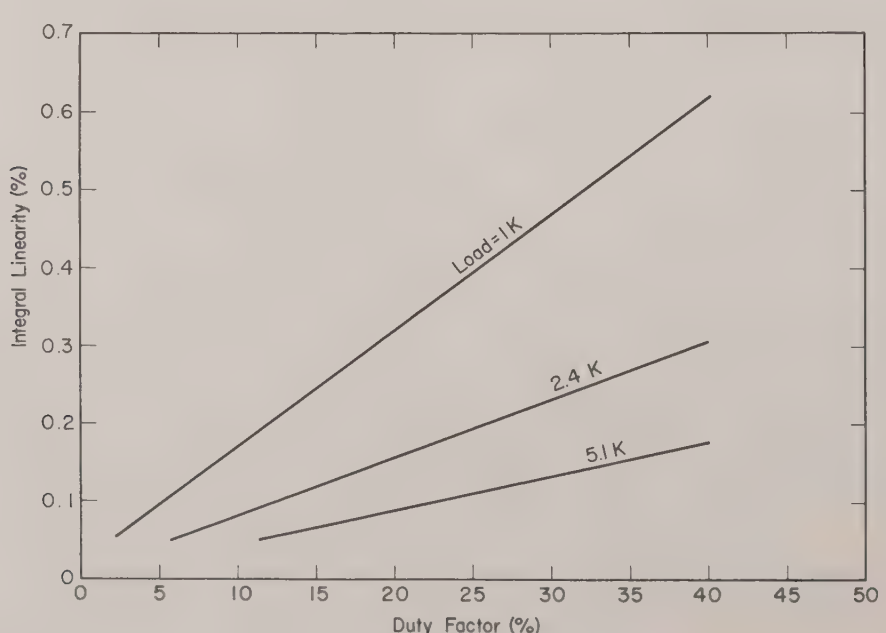


Fig. 2. Integral linearity vs. output loading.

3.2 STABILITY TESTS

The stability of the Model PB-1 is a function of (a) ambient temperature, (b) ac line fluctuations, and (c) drift of the internal components.

(a) The overall TC (temperature coefficient) of the Model PB-1 is 0.0033% of the pulse amplitude per °C or 33 μv/°C, whichever is larger. The major limitation on the TC is the chopper which employs two compensating base-emitter junctions. If excessive current is drawn from this chopper, the two base-emitter TC's will be unequal. Therefore the minimum load resistance is set at 1K to limit the peak current to 10 ma.

In addition, the TC of the output resistance has less than a 10% effect on the pulse amplitude if the load resistance is greater than 1K.

(b) An ac line fluctuation from 105-125 vac will change the bias current in the 11.8 v zener diode. This produces a maximum change of approximately 3 mv in 11.8 v (about 0.026%).

(c) The effects of temperature and ac line fluctuation are predictable and can be controlled to the extent desired by air-conditioning and ac line regulation. The cause and control of long-term drift is less tractable. However repeated tests of several Model PB-1's show that the 48 hr drift of pulse amplitude is less than 0.03%.

In view of the above considerations, the Model PB-1 may be expected to be stable to better than 0.1% for monitoring a linear system for at least 48 hrs or for checking the TC of other instruments undergoing temperature tests.

3.3 REPETITION RATE TESTS

Referring to Fig. 1, the circuit to the left of the chopper may be reduced by Thevenin's Theorem to an equivalent voltage source in series with an impedance. The value of this series impedance depends upon the setting of the AMPLITUDE potentiometer. As this series impedance is increased, the output regulation becomes poorer, and the output amplitude shifts more at high duty factors.

In Fig. 1, the highest series impedance occurs with the potentiometer wiper at midpoint, or about 500 on the dial. However, in the actual circuit there is about 70 ohms in series with the potentiometer so the highest impedance occurs at about 650 on the dial. Consequently, for minimum amplitude shift with duty factor, it is best to operate the AMPLITUDE control near the top or bottom of its dial. In addition, at any AMPLITUDE setting, the greater the loading, the greater the amplitude shift (or reduction). The interrelations between these factors are shown in Figs. 3a - 3e for the Model PB-1.

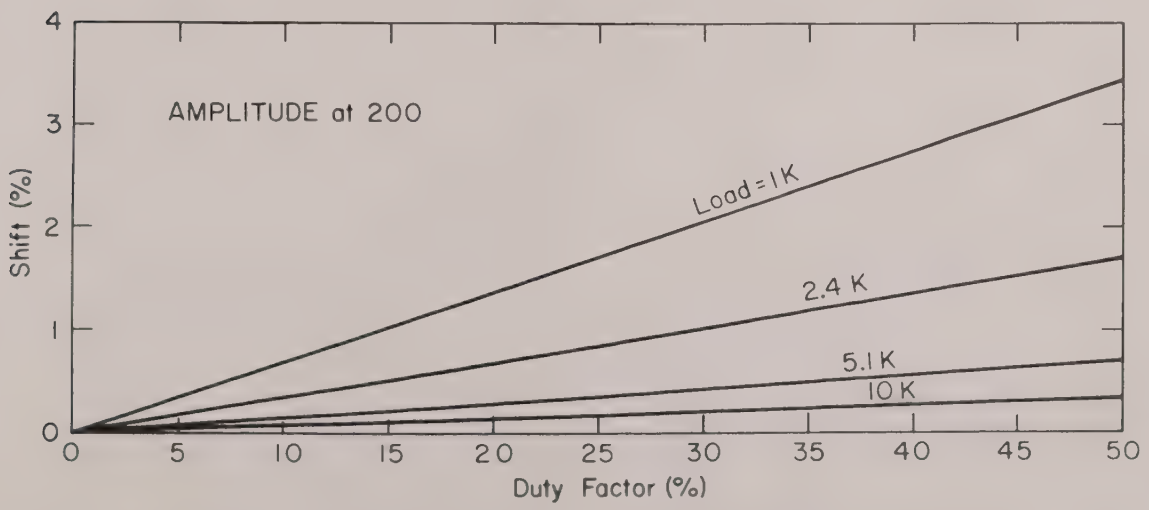


Fig. 3a. Amplitude shift vs. duty factor. AMPLITUDE control at 200.

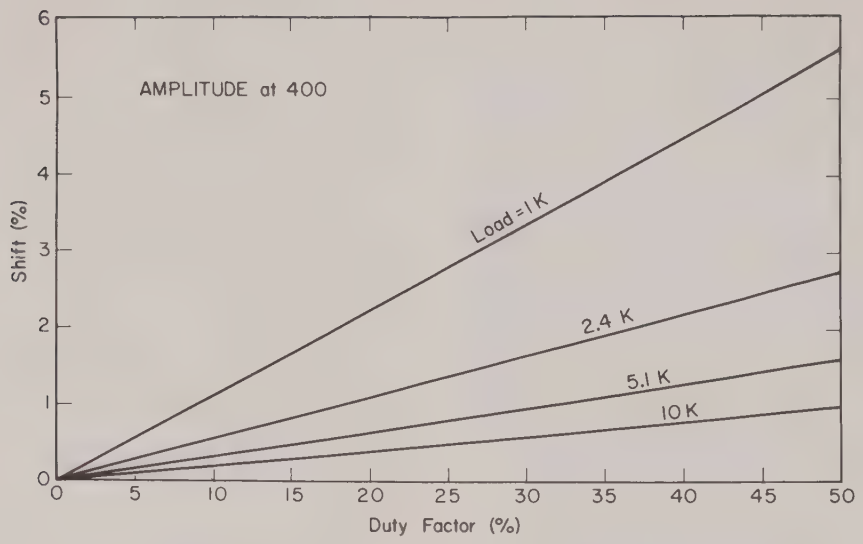


Fig. 3b. Amplitude shift vs. duty factor. AMPLITUDE control at 400.

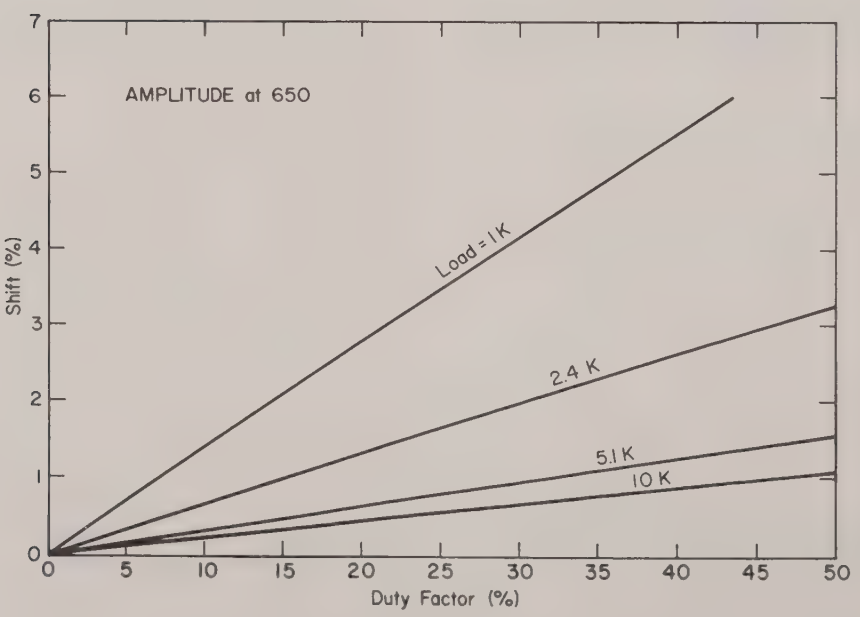


Fig. 3c. Amplitude shift vs. duty factor. AMPLITUDE control at 650.

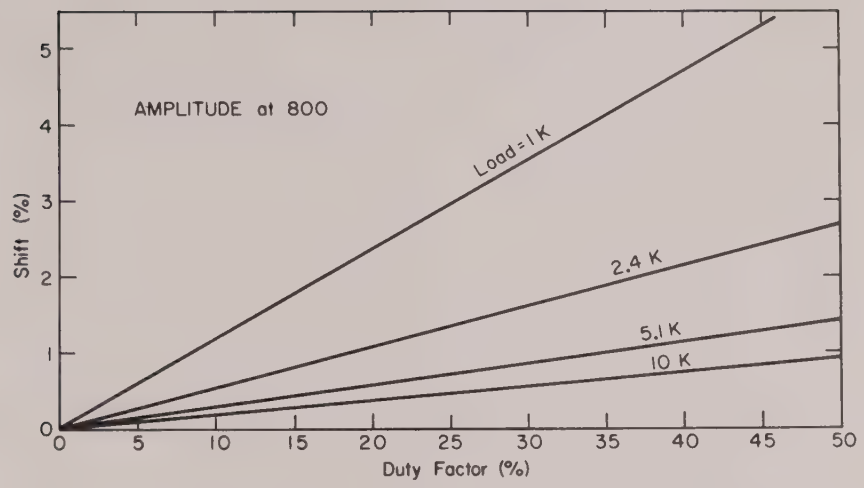


Fig. 3d. Amplitude shift vs. duty factor. AMPLITUDE control at 800.

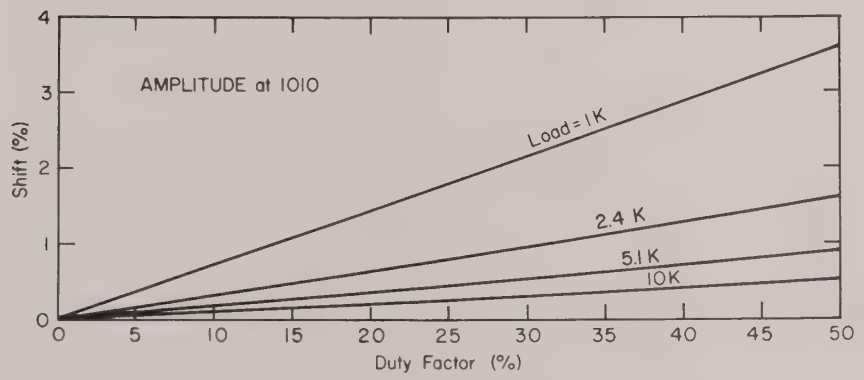


Fig. 3e. Amplitude shift vs. duty factor. AMPLITUDE control at 1010.

As mentioned in Sec. 2.6, the loading effects of the ATTENUATOR in the x10 and x100 positions are the same as an external 1K and 10K load, respectively.

3.4 RISE TIME TESTS.

Often it is found that the linearity of an instrument depends upon the rise-time of the input pulse. Too fast an input rise-time causes feed-through effects so that input pulses appear larger than they actually are. Slow rise-time pulses lose amplitude in passing through coupling capacitors so that they appear smaller than they actually are. Linearity tests at different rise-times will often show these effects. The RISE TIME control performs this function by integrating the output pulses.

It is important to recognize that the amplitude of the output pulse may decrease as the RISE TIME setting is increased because of integration. The amplitude reduction will be less than 0.1% if the pulse width is at least four times the RISE TIME setting.

Fig. 4 shows the effect of the RISE TIME control on the amplitude of the output pulses as a function of pulse width. The pulse width (going into the integrator) is determined by setting the RISE TIME at 0.05 μsec and observing the length of the flat top of the pulse on a scope.

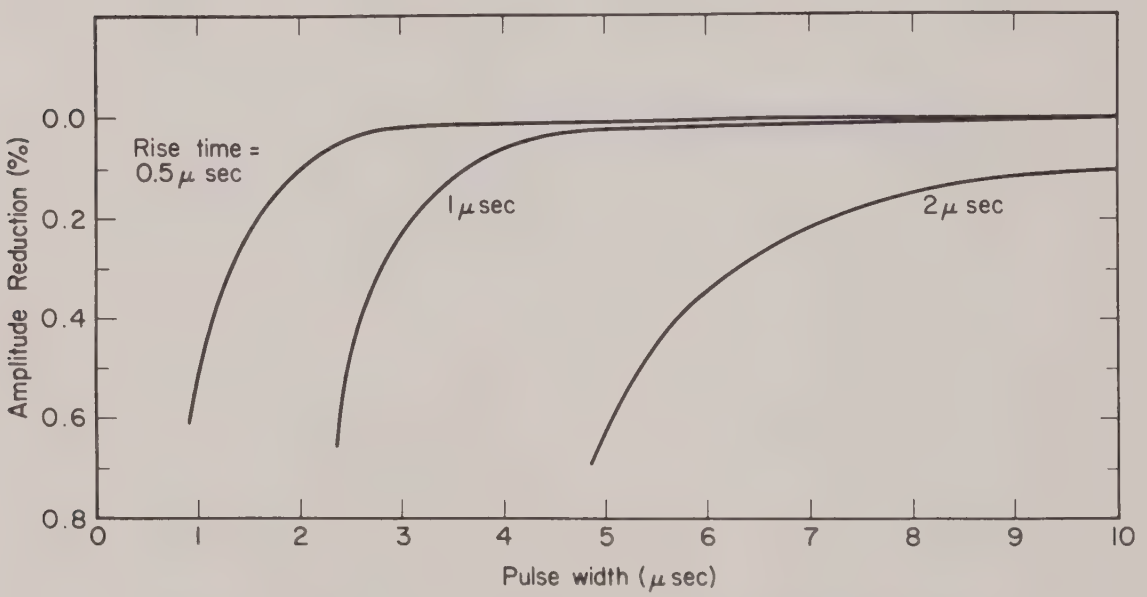


Fig. 4. Amplitude reduction vs. pulse width for different RISE TIME settings.

3.5 TAIL PULSES (or Exponentially Decaying Pulses)

To obtain tail pulses, set the WIDTH controls to minimum, ATTENUATOR at X1, and connect the output to a high impedance (50K or more). Different length tails to over 100 μsec are obtained by rotating the RISE TIME control.

The rising edge of the pulse occurs when the chopper passes current from the 100 ohms output impedance into the total shunt capacitance (which includes the internal integrating capacitance and external cable). The tail occurs when the chopper is open and the charge on this capacitance discharges through an internal 30K resistor. Additional shunt capacitance may be added at the output to lengthen the tail. Load resistors comparable to the 30K internal resistor will shorten the tail.

If a long tail is desired, but the load resistance is small, connect the output to a high impedance divider and tap the signal off at a lower level. The x10 attenuator shunts the integrating capacitance with 1K so it will generally not be used in this application. The x100 attenuator with its 10K internal shunt may be useful.

CIRCUIT DESCRIPTION

SECTION 4

4.1 FUNCTIONAL DESCRIPTION

Refer to Schematic No. PB-101 at the back of the manual. The following discussion deals first with the functional blocks and then circuit details.

Q1 and Q2 are in a free-running multivibrator that controls the repetition rate of the output pulses. The output of the multivibrator is fed to a width one-shot, Q6 and Q7. The output of the width one-shot drives Q8 into saturation which causes current to flow in T2's primary. T2, Q9, and Q10 constitute a chopper which is closed for a period of time equal to the width pulse. During this closure time, the chopper samples the voltage on C15 and C16, thereby generating pulses which are passed to the output connector via an integrator and attenuator.

4.2 CIRCUIT DETAILS

Reference to the various waveforms in Schematic No. PB-101 will be helpful in the following discussion.

Two outputs are taken from the free-running multivibrator, Q1 and Q2. One output from the collector of Q2 is differentiated by C13 and R24, amplified by Q3, and appears across the 120 ohms collector resistance, R29, to provide a TRIGGER OUT or sync pulse. The other output is obtained from the emitter of Q2 and passes through emitter follower Q4. The output of Q4 is differentiated by C18 and R39 to provide a trigger for the width one-shot, Q6 and Q7.

The base of Q6 is more negative than the base of Q7 by the voltage drop across CR8. The proper bias level for these bases is set by Q5. Transistor Q6 is normally nonconducting while Q7 is conducting. However, a trigger pulse at the base of Q6 drives it into conduction and generates a negative pulse at its collector which in turn cuts off Q7. Then, Q7 is cut off for a period of time set by C21 (or C22), R52 and R51. During this time a positive pulse appears at the collector of Q7 which drives Q8 into saturation.

While Q8 is in saturation, approximately 130 ma flows into its collector via R41 and the primary of T1. The secondary current of T2 drives Q9 and Q10 into saturation. Trimmer potentiometer R37, PEDESTAL ADJUST, controls the current in Q9 and Q10 so that their saturation voltages are exactly equal and opposite. The chopper generates output pulses by sampling the voltage on C15 and C16. This voltage is derived from the zener diode CR6 via the adjustable AMPLITUDE potentiometer, R26.

The zener diode is connected to the POLARITY switch, S4, so that its positive or negative end is grounded. In this way, the chopper samples either a positive or negative dc voltage to provide pulses of either polarity. Simultaneously, with the grounding of one side of the zener diode, the positive or negative side of the power supply is grounded.

The bleeder current for the zener diode and the AMPLITUDE potentiometer is obtained via R16 or R20. The output voltage across the zener is nominally 11.8 v and is reduced by R18 and the rear-panel trimmer, 10.1 V PULSE ADJUST, to approximately 10.15 v. There is approximately a 50 mv drop across the chopper so 10.1 v pulses appear at the output.

The wiper arm of the AMPLIFIER potentiometer is connected to rear panel pin-jack, J2, which is used for monitoring the dc reference voltage.

The output of the chopper at the collector of Q9 passes into R45, R47, and R48. These resistors with the series resistance of the chopper provide 100 ohms output impedance. The junction of these resistors is connected to capacitors on switch S5 which together provide the R-C time constant for integration of rise times.

The pulses then pass into the ATTENUATOR, S6, and to the PULSE OUT connector. Note that with the ATTENUATOR at x10 the shunt load is approximately 1K, and at x100, is approximately 10K.

4.5 POWER SUPPLY

Refer to Schematic No. PB-102. The ac input is stepped down to approximately 30 v by T1 and full-wave rectified by diodes CR1 - CR4. The output of the rectifier is filtered by R2 and C1 and then connected to the feed-back regulator, Q1 - Q4. The operation of the regulator is as follows:

The output current passes through series transistor Q4, whose base current is controlled by emitter follower Q3. The current at the base of Q3 is obtained from the collector of Q2.

Q1 and Q2 are in a difference amplifier, one side of which is referenced to zener diode CR5 and the other side referenced to the wiper arm position on trimmer R9 (labeled on the schematic as "22 v adj."). R9 is connected to the regulator output voltage via R8 and R10.

If the output voltage should change due to line or load variations, the change will appear at the base of Q2 via R9. The collector current of Q2 will change, and through Q3, the base current of Q4 will change. These changes are in a direction to re-establish the previous conditions.

R9 is normally adjusted to provide 22 v $\pm$ 1% output voltage. This tolerance is required to set the bleeder current in the zener diode CR6 (Schematic No. PB-101) to 7.5 ma for the best temperature coefficient.

The 120 cps ripple out of the regulator is approximately 5 mv peak-to-peak. At a high output duty factor, larger amplitude transients will appear on the 22 v bus because of the usual limitation on transients response of ac regulators. However, this does not affect the specified performance of the instrument.

MAINTENANCE

SECTION 5

5.1 GENERAL

There are three trimmer potentiometers in the Model PB-1: PEDESTAL ADJUST, 10.1 V PULSE ADJUST, and 22 V ADJUST. Their physical locations are shown on Schematic PB-101 and PB-102. These trimmers are preset at the factory but may requre resetting if components are replaced or if long term drift occurs.

The adjustment procedures are described below. A Tektronix 541 Scope with an L and Z plug-in (or equivalents) is required. The adjustments should be made with FREQUENCY at 1 KC, WIDTH at 10 μSEC, ATTENUATOR at x1, and RISE TIME at 0.05 μSEC.

5.2 PEDESTAL ADJUST

Trimmer R37 adjusts the saturation current in Q9 and Q10 so that their collector-emitter saturation voltages will cancel and the droop on top of the pulse is minimized. In general, it is necessary to make a compromise between saturation voltage cancellation and acceptable droop.

The adjustment procedure is as follows: Set the AMPLITUDE potentiometer at its minimum setting of 0.1 v. Connect the PULSE OUT to the Tektronix L plug-in with a 1K termination at the input of the plug-in. Make sure the scope has been compensated for droop or overshoot and set the sensitivity to 50 mv/cm.

Rotate the POLARITY switch to positive and negative positions and check that the respective pulses are 90 mv ± 10 mv and their droops are less than 10 mv. If these conditions do not exist, it will be necessary to readjust the PEDESTAL ADJUST trimmer. The optimum setting is found by successively switching polarities while observing the waveform on the scope as the trimmer is adjusted.

If the adjustment cannot be made to satisfy the above conditions, Q9 and Q10 may require replacement. These transistors are selected for minimum switching transient and the best saturation voltage cancellation. Their respective locations in the sockets should not be interchanged. If replacements are required, they should be ordered from the factory.

5.3 10.1 V PULSE ADJUST

It is necessary to use the Tektronix Z plug-in for this adjustment. Connect the PULSE OUT to the high impedance (100K or greater) input of the oscilloscope. Then adjust the rear panel trimmer marked 10.1 V PULSE ADJUST while observing the scope. During this test, continually check the drift of the scope by setting the comparison voltage to zero and observing the position of the base-line of the pulse. Adjust the maximum point on the pulse top to 10.1 v. Double check to see that the DF is low.

5.4 22 V ADJUST

This adjustment provides 22 v ± 1% from the power supply regulator. A 1% voltmeter is required so the current in the reference zener diode CR6 may be set for optimum temperature compensation. The Tektronix Z plug-in unit is convenient for this measurement.

The 22 V ADJUST is conveniently checked at tie-points H or I, one of which is grounded (depending on polarity setting) through the POLARITY switch. These tie points are shown in the figure marked TRIMMER POT LOCATIONS on Schematic PB-101.

5.5 CALIBRATION

The linearity and calibration of the AMPLITUDE control may be checked with the Tektronix Z plug-in. The Z plug-in should first be checked against an adjustable dc source that has been calibrated with a 0.05% digital voltmeter.

5.6 MARGINAL TESTS

Two marginal tests should be made on the Model PB-1 during maintenance. These tests confirm that component tolerances are within initial design limits and that continual reliable operation is to be expected. The tests are as follows:

(a) Vary the ac input voltage from 105-125 vac. Check that the 22 v output of the regulator (at tie-points H and I) does not change more than

80 mv. The 80 mv change of the 22 v may be checked by using a sensitive scale of a standard voltmeter and bucking out approximately 22 v with another external supply. The Tektronix Z plug-in may also be used for this test.

(b) Set the pulse out AMPLITUDE at max. and the duty factor at about 20%. Adjust the 22 V ADJUST trimmer on the regulator board over a ±15% range (from about 19 to 25 vdc). The output pulses should continue to appear with only slight changes in width, repetition rate, and amplitude. Finally, readjust the trimmer to 22 v ±1%.

5.7 TROUBLE-SHOOTING

The schematics of the Model PB-1 show the important voltages and waveforms in the instrument. If trouble occurs, it is best to inspect these waveforms and voltages in an orderly manner, starting from the free-running multivibrator and proceeding through the stages to the output. Note that the waveforms show the dc voltages at the upper and lower limits of their excursions which is helpful in establishing quiescent levels.

During these tests it should be remembered that the power supply is floating and is grounded only through the POLARITY switch.

PARTS LIST

ABBREVIATIONS

cer	ceramic	uh	microhenry
comp	composition carbon	uf	microfarad
EMC	electrolytic,metal case	pf	picofarad
mic	mica	pos	positions
myl	mylar	tan	tantalum
k	kilohm	v	working volts dc
meg	megohm	var	variable
m	milli	w	watts
MF	metal film	ww	wirewound

CAPACITORS

C1	500 uf	EMC	50 v	
C2	.01 uf	myl	200 v	10%
C3	25 uf	EMC	25 v	
C4	50 uf	EMC	25 v	
C5	.005 uf	cer	200 v	
C6	25 uf	EMC	25 v	
C7	47 uf	tan	20 v	10%
C8	4.7 uf	tan	35 v	10%
C9	.47 uf	myl	200 v	10%
C10	.047 uf	myl	200 v	10%
C11	.0047 uf	myl	200 v	10%
C12	470 pf	mic	200 v	5%
C13	250 pf	cer	200 v	
C14	.01 uf	myl	200 v	10%
C15	75 uf	EMC	15 v	
C16	75 uf	EMC	15 v	
C18	150 pf	cer	200 v	
C19	25 uf	EMC	25 v	
C20	47 pf	mic	200 v	5%
C21	430 pf	mic	200 v	5%
C22	.0047 uf	myl	200 v	10%
C23	50 uf	EMC	25 v	
C24	25 uf	EMC	25 v	
C25	330 pf	mic	200 v	5%

CAPACITORS

C26	.001 uf	myl	200 v	10%
C27	.0033 uf	myl	200 v	10%
C28	.0068 uf	myl	200 v	10%
C29	.015 uf	myl	200 v	10%
C30	25 uf	EMC	25 v	
C31	25 uf	EMC	25 v	

CHOKE

L1	10 uh	choke

DIODES

CR1	1N3253
CR2	1N3253
CR3	1N3253
CR4	1N3253
CR5	1N821
CR6	1N944
CR7	1N34A
CR8	1N626
CR9	1N34A
CR10	1N34A
CR11	1N34A

RESISTORS

R1	100 k	½ w	comp	5%
R2	13 ohms	1 w	comp	5%
R3	2.2 k	½ w	comp	5%
R4	13 ohms	1 w	comp	5%
R5	1.8 k	½ w	comp	5%
R6	33 k	½ w	comp	5%
R7	9.1 k	½ w	comp	5%
R8	511 ohms	½ w	MF	1%

RESISTORS

R9	200 ohms	½ w	trimmer	
R10	1.47 k	½ w	MF	1%
R11	5.1 k	½ w	comp	5%
R12	2.7 k	½ w	comp	5%
R13	680 ohms	½ w	comp	5%
R14	2.7 k	½ w	comp	5%
R15	75 k	2 w	var	
R16	365 ohms	½ w	MF	1%
R17	620 ohms	½ w	comp	5%
R18	34.8 ohms	¼ w	MF	1%
R19	3.9 k	½ w	comp	5%
R20	365 ohms	½ w	MF	1%
R21	50 ohms	½ w	trimmer	
R22	220 ohms	½ w	comp	5%
R23	2.2 k	½ w	comp	5%
R24	51 ohms	½ w	comp	5%
R25	150 ohms	½ w	comp	5%
R26	500 ohms	5 w	var	.1% lin.
R27	4.7 ohms	2 w	ww	1%
R28	51 ohms	½ w	comp	5%
R29	120 ohms	½ w	comp	5%
R30	150 ohms	½ w	comp	5%
R31	2 k	½ w	comp	5%
R32	2 k	½ w	comp	5%
R33	1.3 k	½ w	comp	5%
R34	750 ohms	½ w	comp	5%
R35	100 ohms	½ w	comp	5%
R36	47 ohms	½ w	comp	5%
R37	50 ohms	½ w	trimmer	
R38	750 ohms	½ w	comp	5%
R39	680 ohms	½ w	comp	5%
R40	47 ohms	½ w	comp	5%
R41	150 ohms	2 w	comp	5%
R42	20 k	½ w	comp	5%
R43	220 ohms	½ w	comp	5%
R44	560 ohms	½ w	comp	5%
R45	51.1 ohms	½ w	MF	1%
R46	560 ohms	½ w	comp	5%
R47	82.5 ohms	½ w	MF	1%
R48	84.5 ohms	½ w	MF	1%
R49	30 k	½ w	comp	5%
R50	100 k	½ w	comp	5%
R51	3.0 k	½ w	comp	5%

RESISTORS

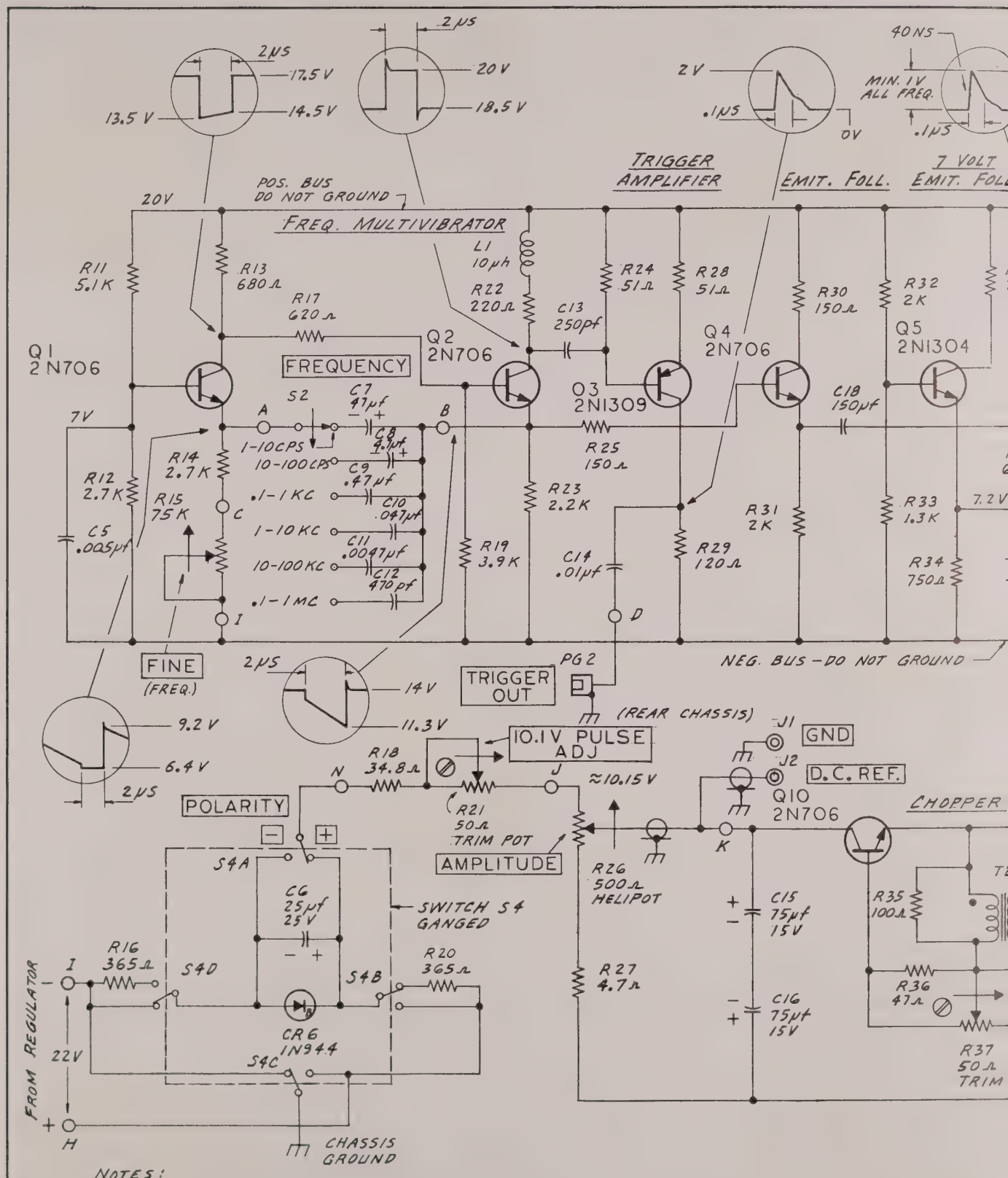
R52	25 k	2 w	var	
R53	680 ohms	½ w	comp	5%
R54	39 ohms	½ w	comp	5%
R55	5.1 k	½ w	comp	5%
R56	10 k	½ w	MF	1%
R57	909 ohms	½ w	MF	1%
R58	10 k	½ w	comp	5%
R59	110 ohms	½ w	MF	1%
R60	100 ohms	½ w	MF	1%

TRANSFORMERS

T1	Power Transformer, Triad F-40X
T2	Pulse Transformer, Berkeley Nucleonics PB-101

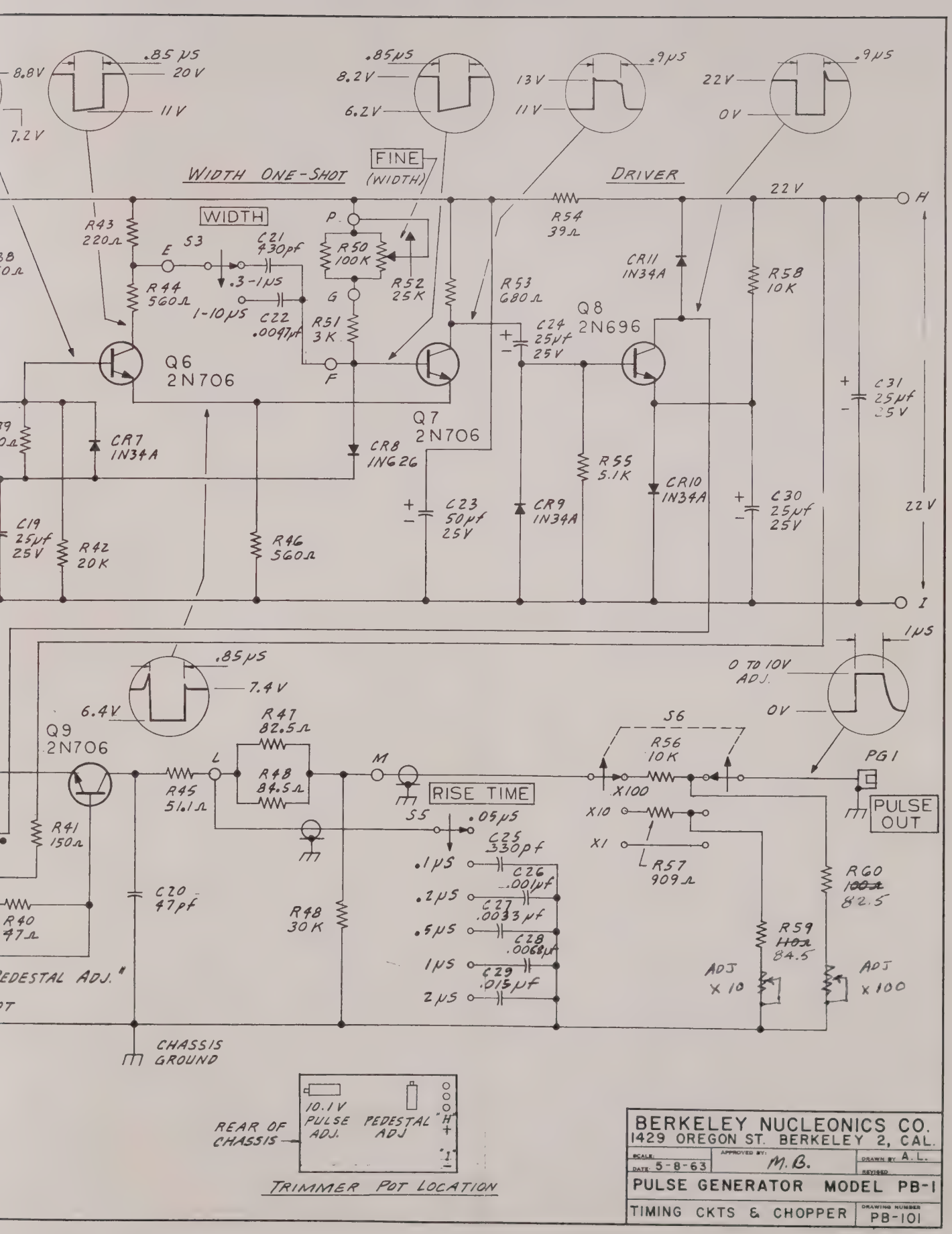
TRANSISTORS

Q1	2N1303	
Q2	2N1303	Power Supply
Q3	2N1303	
Q4	2N1360	
Q1	2N706	
Q2	2N706	
Q3	2N1309	
Q4	2N706	
Q5	2N1304	
Q6	2N706	
Q7	2N706	
Q8	2N696	
Q9	2N706	selected
Q10	2N706	selected



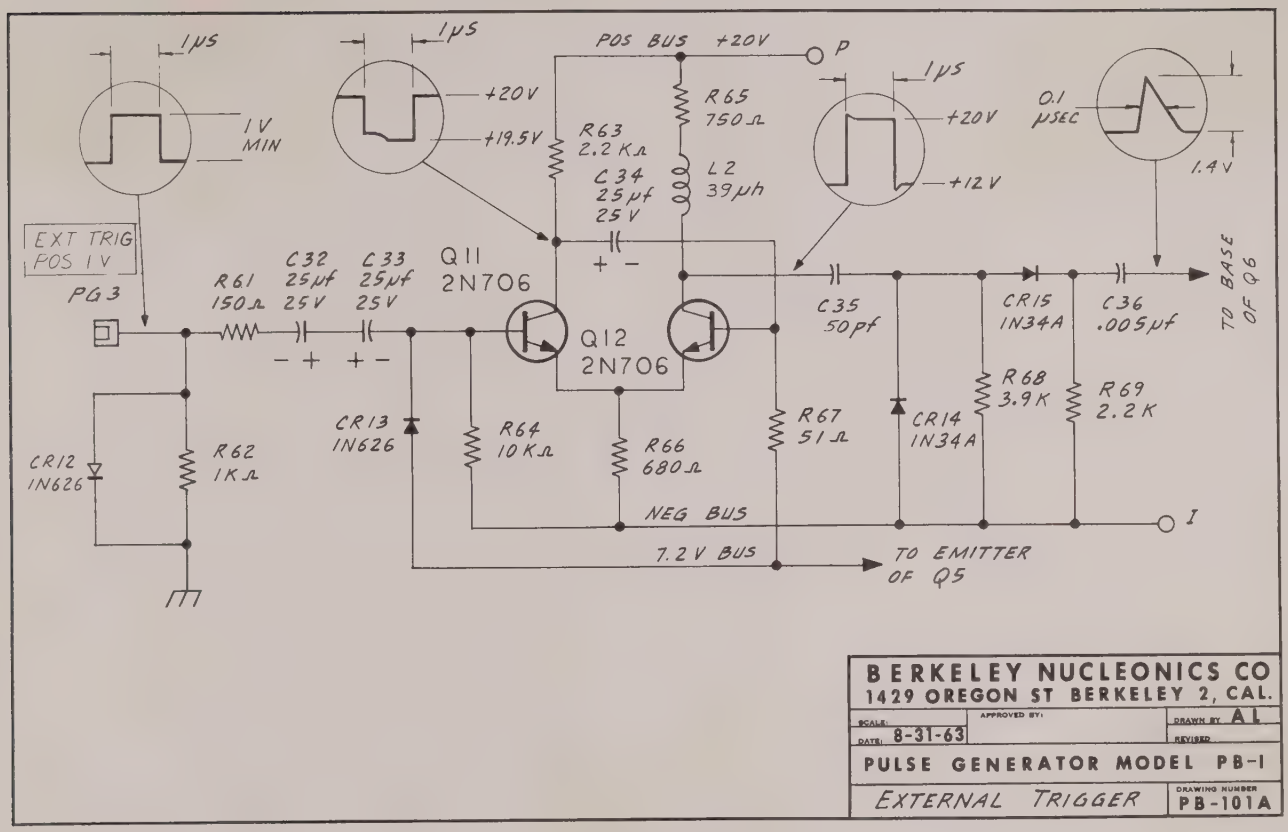
NOTES:

1. NEG AND POS BUS ARE GROUNDED THROUGH POLARITY SWITCH. ATTACH SCOPE-GROUND ONLY TO CHASSIS-GND.
2. WAVEFORMS AND VOLTAGES TAKEN WITH POLARITY SWITCH AT "+"; FREQ. SWITCH AT 10-100 KC; WIDTH AT 1μS. REFERENCE IS AT CHASSIS GROUND.



BERKELEY NUCLEONICS CO. 1429 OREGON ST. BERKELEY 2, CAL.	
SCALE: DATE 5-8-63	APPROVED BY: M.B. DRAWN BY A.L. REVISED
PULSE GENERATOR MODEL PB-1	
TIMING CKTS & CHOPPER	DRAWING NUMBER PB-101

EXTERNAL TRIGGER MODIFICATION



CAPACITORS

C32	25 uf	EMC	25 v
C33	25 uf	EMC	25 v
C34	25 uf	EMC	25 v
C35	50 pf	cer	200 v
C36	.005 uf	cer	200 v

CHOKE

L2	39 uf

DIODES

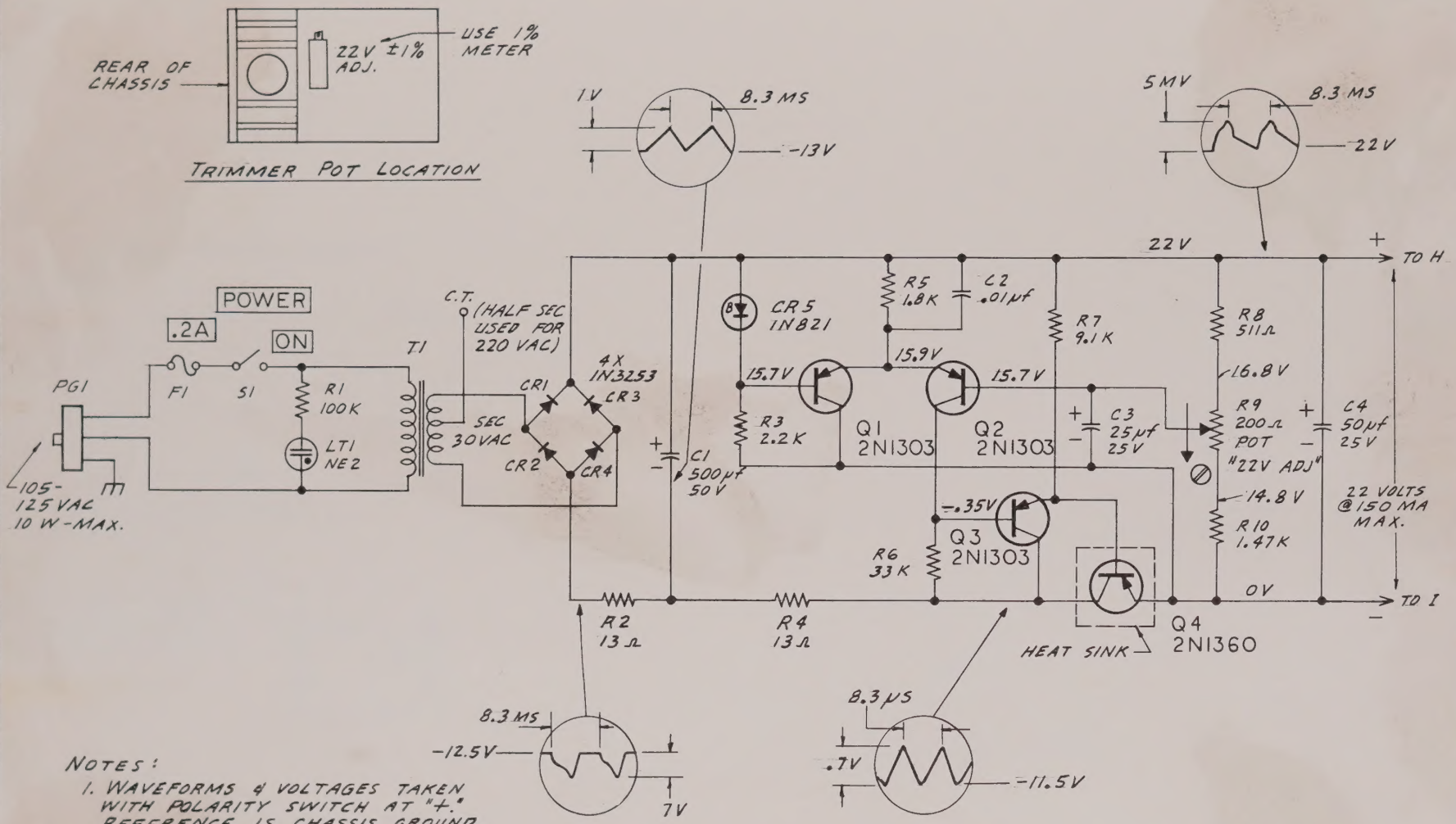
CR12	IN626
CR13	IN626
CR14	IN34A
CR15	IN34A

RESISTORS

R61	150 ohms	½w	comp	5%
R62	1 k	½w	comp	5%
R63	2.2 k	½w	comp	5%
R64	10 k	½w	comp	5%
R65	750 ohms	½w	comp	5%
R66	680 ohms	½w	comp	5%
R67	51 ohms	½w	comp	5%
R68	3.9 k	½w	comp	5%
R69	2.2 k	½w	comp	5%

TRANSISTORS

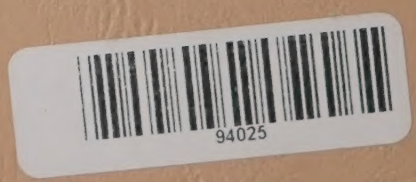
Q11	2N706
Q11	2N706



NOTES:

1. WAVEFORMS & VOLTAGES TAKEN WITH POLARITY SWITCH AT "+." REFERENCE IS CHASSIS GROUND. AC INPUT SET AT 115VAC. FREQ. SWITCH AT 1-10 CPS
2. AC LINE REGULATION: 22 VDC CHANGES 80 MV WITH 105-125 VAC VARIATION.

BERKELEY NUCLEONICS CO. 1429 OREGON ST. BERKELEY 2, CAL.		
SCALE: DATE: 5-8-63	APPROVED BY: M.B.	DRAWN BY A.L. REVISED
PULSE GENERATOR MODEL PB-1		
POWER SUPPLY		DRAWING NUMBER PB-102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